Climate and Weather Information for Small- and Medium-size Water Utilities

# Adapting Stormwater Management to a Changing Climate in the Mid-Atlantic and Urban Northeast Regions

## Science and Trends

According to the U.S. Fourth National Climate Assessment (NCA4), precipitation trends in the Northeast show increases in rainfall intensity[1]. These trends are greater than in other parts of the U.S. and are projected to continue into the future. Under a high future emissions scenario, monthly precipitation is projected to be higher than historical averages from December through April; while rainfall is expected to remain the same during summer months. Annual average temperatures are also rising, which is further exacerbated in cities in the Northeast due to the urban heat island effect. Observed and projected increases in temperature, storm frequency and intensity, and sea levels are compounded by factors such as land use and land cover changes.

1 Dupigny-Giroux, L.A., et al., 2018: Northeast. In *Impacts, Risks, and Adaptationin the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., et al. (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 669–742. doi: 10.7930/NCA4.2018.CH18

## Purpose of the Workshop Series

This workshop series was designed by NOAA and the Water Research Foundation to improve its delivery of information resources for small- and medium- size water utilities useful for building their resilience to a changing climate. Each workshop was organized by NOAA's regional partners and addressed issues identified by and for each region. The workshops offered a forum for exchanging ideas to:

- Identify gaps and improve NOAA climate and weather-related tools and information resources;
- Provide timely and relevant weather and climate information and raise regional-scale awareness of NOAA tools and resources;
- Build regional connections that support small-scale utility decision making;
- Develop improved communication materials and enhance NOAA's tools for local decision making.

## The Mid-Atlantic and Urban Northeast Workshop

Because extreme rainfall events have exposed critical gaps in planning, the Consortium for Climate Risk in the Urban Northeast (CCRUN) and the Mid-Atlantic Regional Integrated Science and Assessment (MARISA) focused this workshop on urban stormwater management. This workshop examined the challenges of integrated planning within today's regulatory context, discussed decision support needs for climate resilience planning, and presented innovative strategies for how to integrate climate modeling into hydrologic and hydraulic modeling. Participants discussed challenges, uncertainties and next steps, and heard from exemplar cities that have begun to move forward with incorporating climate resilient design into their stormwater planning and management.

## Summary

Planners and engineers for utilities, municipalities, departments of transportation and public works, and other infrastructure agencies are increasingly turning attention to coping with extreme precipitation events. These efforts have been highly variable and do not yet reflect a consensus on best practices for analysis, planning, and design. Some workshop participants were concerned that, without top down mandates or adoption by formally recognized bodies, new methods for stormwater modeling, planning, and design may not be adopted at the local level. Furthermore, there is still a mismatch in the data produced by climate scientists and the data needs of stormwater managers. A wide range of strategies are available to downscale global climate model outputs to the local scale, but small- to medium-size communities may not have the time, resources, or capacity to properly vet and compare these approaches. Some may prefer simpler and more widely accepted tools, even if these represent major simplifications.

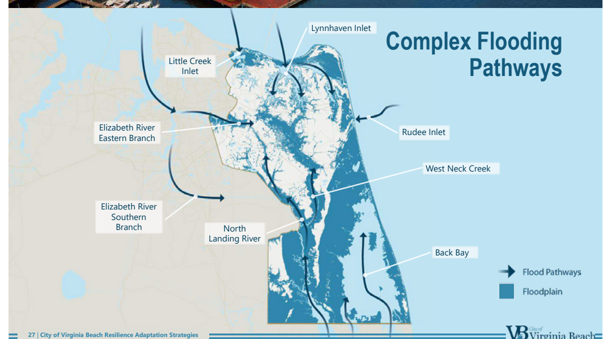
Workshop Date :: March 2020

## Case Studies

**Designing the Coastal Community of the Future (Doug Beaver, Chief Resilience Officer, City of Norfolk, VA).** As a member of the 100 Resilient Cities Initiative, Norfolk is implementing a $112 million strategy to build resilience by addressing three challenges in the Ohio Creek Watershed: flooding from a rising sea level; economic risk from overreliance on two industries; and a disconnected neighborhood with concentrated poverty.

**Virginia Beach Sea Level Wise Comprehensive Stormwater Plan (Tom Utterback, Administrator and C.J. Bodnar, Technical Services Manager, Public Works Stormwater Engineering Center, Virginia Beach, VA).** All stormwater functions in the city were consolidated into a single stormwater engineering center, which conducted a detailed inventory of the city's stormwater system to inform the comprehensive Sea Level Wise Adaptation Strategy.

**Updating Stormwater Management Plans: Pittsburgh's Unified Approach (James Stitt, Sustainability Manager, Pittsburgh Water & Sewer Authority).** Recognizing that water quality and flooding issues were symptoms of ineffective stormwater management, the city eliminated silos and adopted a true integrated stormwater management plan closely tied to the city's development.



## Lessons Learned

### Innovative Regulatory and Policy Controls to Address Practical Challenges

Urban water managers make decisions that regulate how water flows across and through the urban landscape oriented around multiple goals, including to: protect water quality from stormwater runoff; eliminate overflows from combined and separate sewer systems; reduce flood risks through urban drainage; manage groundwater; improve social equity; and in coastal areas, manage additional flooding from sea level rise and surge. From an operations standpoint, decisions regarding each of these goals are often developed by different administrative units, each of which may have purview over different geographic areas, allocate resources from different budgets, and be subject to different regulations, codes, and standards. Discussion revealed the need for integrated, multi-objective stormwater and wastewater planning but also noted that many barriers still exist, including lack of dedicated funding, public support, and authority.

#### *› Regulatory Context*

Federal regulations are largely silent on how state and local authorities should incorporate projected changes in climate into compliance plans. Methods for incorporating climate projections into stormwater planning and design are not yet standardized and workshop participants have experienced challenges as they have adopted different approaches and implemented adaptive and risk management strategies. One conclusion seemed evident: local water managers are in need of analytical tools and additional policy levers that are appropriate to changing climate conditions.

Participants discussed the need for tools to quantify the ability of stormwater management strategies like green infrastructure to help reduce flood risks. For example, common sizing and design standards for green infrastructure are not scaled for extreme precipitation, which means these facilities cannot fully capture and treat cloudburst rainfall. Further, improved performance monitoring methods for green infrastructure are needed to quantify the stormwater management value of these facilities under extreme precipitation, as part of a broader evaluation of all the co-benefits they provide.

### › Policy Levers

Unprecedented flooding in many communities necessitates changes in policy. To implement policy changes, cities and counties are confronting a number of challenges, including: coordinating various departments that have different stormwater processes; identifying current and future flooding hotspots; and quantifying costs and benefits of stormwater management strategies, particularly when it comes to green infrastructure.

Whether using downscaled climate models, building in additional safety factors, revising level of service standards, or implementing green infrastructure, some localities are revising codes and applying new methods to manage stormwater and flooding. And, while localities control rights of way on streets and implement a range of practices, some communities reported that they may be unable to meet water quality goals without implementing stormwater management practices on private land. Many strategies have been attempted including: innovative rate structures and leveraging upcoming construction projects to incorporate stormwater management goals from the start.

## Modeling Stormwater and Climate Change

### › Hydrologic and Hydraulic Modeling

Perhaps as challenging as understanding changing climate patterns is understanding the behavior of rainfall once it lands on the ground. Many utilities and municipalities have developed hydrologic and hydraulic (H&H) models, but use of these simulation tools to project the impact of extreme precipitation is not straightforward. Extreme conditions may invalidate the calibration of existing models to historical precipitation, for example. Existing H&H models were developed primarily for regulatory purposes to meet water quality goals, and their development often necessitated simplifications (e.g. conduit skeletonization, subcatchment aggregation) that limit their direct use in studies of flooding triggered by extreme precipitation.

Dynamic coupling of models remains tedious and time intensive (e.g., representing coastal hydrodynamics, tidal fluctuations, surges and sea level rise, inflow through storm sewers, overland rainfall-runoff, groundwater flow, etc.). Despite these challenges, innovative strategies have been proposed using existing models to identify hotspots and to align investments with hazard mitigation. In one example, photos were solicited from citizens when flooding occurs to help update and validate models.

### › Precipitation Design Standards in a Changing Climate

Intensity-duration-frequency (IDF) curves based on historical observations are heavily used by stormwater planners. These curves typically are produced by NOAA and sometimes by states and localities. Planners across the Northeast and Mid-Atlantic are recognizing that performance of stormwater infrastructure systems is likely to continue to decline under changing precipitation patterns and that continuing to use statistical values based on historical observations is not useful – and indeed inappropriate – for long-lived infrastructure.

Prior to the workshop, CCRUN hosted four webinars describing some technical approaches to incorporate climate change into the use of synthetic projections of future precipitation time series in the construction of updated IDF curves. For example, a method was developed for New York City to study the historical relationship between current climatic conditions and historical extreme precipitations, as a guide to better understand what future precipitation patterns for the region could look like. The results helped the City develop guidance on sizing of infrastructure designed to protect against extreme rainfall. Meanwhile, NOAA is working to update Atlas 14 for future use.

SCAN ME

› NOAA Workshop Series Website

› MARISA/ CCRUN Workshop Website

**Tools Demonstrated:**

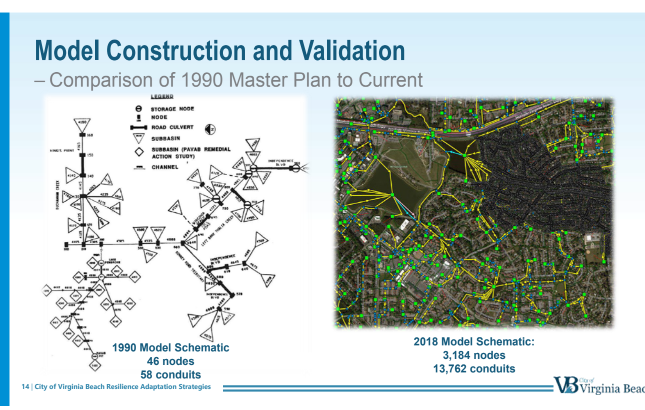
› NOAA Atlas 14

› Climate Resilience Toolkit

› Climate Explorer

› Tides and Currents

› Historical Weather Observations



## Pre-Workshop Webinars:

**Transforming Daily Global Climate Model Precipitation Output for use in Hydraulic/Hydrologic Modeling** by Mark Maimone, Senior Vice President at CDM Smith

› Watch the recorded webinar

**A Practical Stochastic Weather Generator for Exploring Variability in Projected Precipitation Time Series** by Mark Maimone, Senior Vice President at CDM Smith

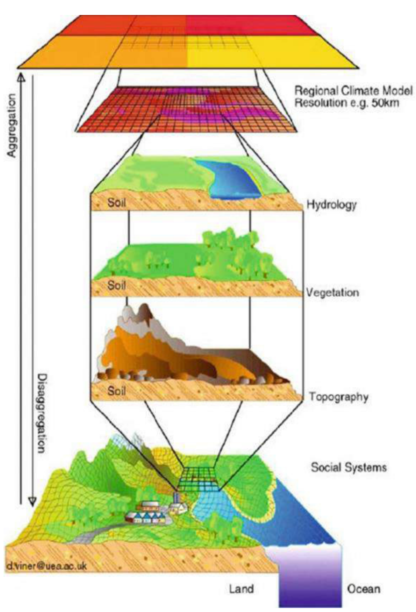
› Watch the recorded webinar

**Using Pressure Change to Stochastically Disaggregate Hourly Precipitation Series from Temperature Projections of Climate Change in The Northeast U.S.** by Ziwen Yu, Assistant Professor at the University of Florida

› Watch the recorded webinar

**Application of a Hybrid Approach to Downscaling and Bias Correcting IDF Curves for NYC** by Eric Rosenberg, Associate at Hazen and Sawyer and Adjunct Professor at Columbia University and Art DeGaetano, Professor at Cornell University

› Watch the recorded webinar




## Steps for incorporating climate modeling into stormwater modeling

### Project Planning

1. Decide what questions, concerns need to be addressed and needed results (IDF, time series)
2. Define project location
3. Define most appropriate emissions scenarios
4. Identify and leverage the expertise of others who have worked in this location

### Select an Analytical Approach

5. Obtain GCM data for the project location
6. Decide whether to use all GCMs or only a subset
7. Select time periods of interest
8. Select desired analytical approach

### Gather Appropriate Observations

9. Obtain gage data for your location
10. Discretize continuous observations into events
11. Rank the events, retaining all properties
12. Modify historical observations using the analytical approach to develop desired products

## Information Needs

Participants indicated that data availability, and the development of consistent methods and best practices for forecasting, design, and balancing the costs and benefits of different management strategies remain top priorities. Over half of participants discussed using climate projections in their planning, but they also cited a number of engineering design challenges, difficulties in considering uncertainty in future climate, and concerns about the inability of climate projections to represent precipitation extremes. Utilities noted that updating stormwater policy to address extreme precipitation is encumbered by the wide range of approaches that are currently being discussed by the research community and the lack of any one standard set of best practices. More information and tools are needed to:

- Quantify the range of uncertainty that is introduced into local decision-making from: the use of multiple global (e.g. GCMs) and regional (e.g. RCMs) climate models; a range of temporally and spatially downscaled datasets; multiple future emissions scenarios; and the range of future time periods.
- Develop stormwater strategies that can be effective under future uncertainty.
- Apply economic analyses to understand a spectrum of cost-benefit tradeoffs and life cycle costs associated with green and grey stormwater infrastructure.

## Next Steps

While there is not yet a consensus on how to incorporate climate change into stormwater planning and design, several cities in the U.S. are forging ahead to demonstrate innovative and practical methods to improve resilience of stormwater systems. These cities' efforts represent valuable examples of adaptive management despite the challenges, and workshop participants cited them as useful in supporting their own climate resilience goals, suggesting that future workshops focus on such practical strategies and models.

To address the needs identified in this workshop, CCRUN developed a summer class in partnership with seven Mid-Atlantic stormwater utilities. The course worked through the strategies to develop "design storms" for the future across a range of projected climate data. MARISA has partnered with the Chesapeake Bay Trust and Carnegie Mellon University to develop a web-based tool to generate station-specific future projected IDF curves in the Chesapeake Bay watershed. Additionally, the workshop identified the need for a best practices guidebook for incorporating downscaled and future projected IDF curves into hydraulic and hydrologic modeling and stormwater planning.


Organized by

Franco Montalto and Korin Tangtrakul, CCRUN, Drexel University

Debra Knopman, Jordan Fischbach, Krista Romita Grocholski, and Michelle Miro, MARISA and the RAND Corporation

Ellen Mecray, NOAA National Centers for Environmental Information

For more information: Krista Romita Grocholski, Krista_Romita_Grocholski@rand.org

https://cpo.noaa.gov/Meet-the-Divisions/Climate-and-Societal-Interactions/Water-Resources